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ANTENNA TOWERS AS WIND TOWER GENERATION PLANTS

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16. Abstract

A variety of wind power generating plants are considered to be installed on FM antenna masts. These include: Savonius rotor, horizontal axis wind wheels, multi-rotor configurations. Power levels vary between 10-20 kW for 100 meter mast heights.

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ANTENNA TOWERS AS WIND TOWER GENERATION PLANTS

Hans Pigge*

INTRODUCTION

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According to the reassignment of wavelengths for radio broadcasting made at the Copenhagen wave band conference in 1950, new transmission installations will be built over the next few years. There are a very limited number of transmitters having their own wavelength in Germany within the medium wave band. This means that FM will certainly be used. In addition, television will most likely be introduced in Germany in the near future.

This means that there will be a considerable number of new FM stations, because their range is limited. In order to supply the public, a much denser transmission network is required than was the case before using medium wave band transmitters. Obviously these new structures will be very costly. There is a question of whether the antenna towers could not also at the same time be used for wind tower generation plants but which would thereby make the operation of the transmitters cheaper. In the following we will briefly describe the design of such a system and we will restrict ourselves to the FM antenna installations.

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* Hameln

** Numbers in the margin indicate pagination of original foreign text.

IDENTICAL CONDITIONS

First of all it should be established that the same conditions apply for both applications. First of all the antenna installations must be as high as possible in order to provide good propagation and must be built in an open area, i.e. that is at the tops of mountains or in the flat land on relatively high towers. Such locations at the same time are very favorable for building wind power generation plants. In addition, the order of magnitude of the energy which can be produced by wind power generating stations is about the order of magnitude required for FM transmitter operation, considering the usual antenna mast types.

Thirdly, there is also the requirement for supplying the transmitter installations with emergency power sources in order to protect them against power failures. Normally, the transmitter will be connected with a public network, so as to provide power during periods of no wind.

These three points demonstrate that it will probably be profitable to use the mast for two purposes. This is true even if we consider the fact that if a wind power generation installation is built within the mast, additional funds will be required in order to strengthen the tower and for building the wind generation plant itself. These additional costs are offset by the fact that the current supply will be independent of any outside source. Sometimes there will be considerable savings in line costs. This is especially important during exceptional periods of operation during which it is very important to have undisturbed operating conditions.

DESIGN EXAMPLES

a) Wind wheels with a horizontal axis

Let us address ourselves to the question of how it is most appropriate to use antenna towers, the heights of which usually vary between 50 and 100 m, for a wind power generation installation. It is natural to assume that the tip [1] is the logical location for a wind wheel having a horizontal axis, if the mast has several guy wires, (unless the mast already has FM antennas). In this type of construction it becomes necessary to make the mast much more stable if the point of application of the wind force is at the tip of the mast, which is the weakest mechanical point on the mast. It must be made much more stronger than conventional lattice or shell construction masts. If large scale wind power generation plants with a propeller diameter of up to 100 m are to be installed [2], one must also make sure that the radiation of the electromagnetic waves is not impeded in any way. This means that the wind wheel can only be attached to the tip of the mast in certain exceptional cases.

There are many more application possibilities, as shown in Figure 1, if the wind wheel is installed on a ring-shaped rotatable gondola about three quarters of the length of the mast above the ground. There are no technical difficulties associated with this solution. In order for the mechanical construction of the gondola not to be too heavy, it is possible to install several wind wheels on various floors above each other. Because of the distributed wind force application points, this reduces the costs of the tower construction. Approximate calculations show that the total construction costs are about 50% more than the construction costs of an antenna tower of the same height. This reduces the main cost of a wind power generation plant considerably.

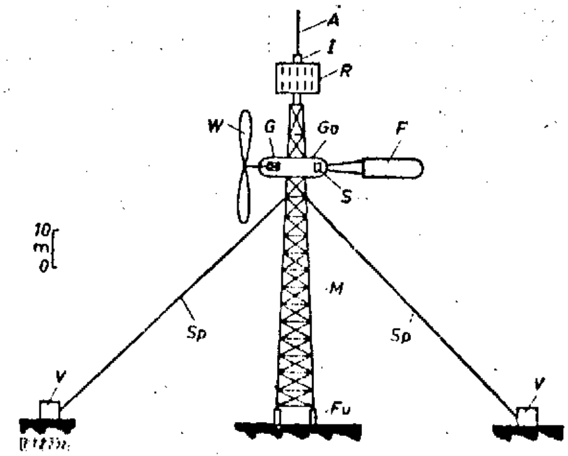

Figure 1. Wind power generation installation with wind wheel at about 3/4 of the mast height, SM antennas on the top of the mast.

A- FM antenna; F- wind vane; Fu- foundation; G- generator
Go- gondola; I- insulators; M- mast; R- directional antenna,
S- switching room; Sp- guy wires; V- anchors; W- wind wheel

The effective power N_e in kW which can be expected according to A. Betz [3] (wind wheel diameter D, [m], wind velocity v [m/sec], efficiency η = 70% amounts to $N_e = 0.2 \cdot 10^{-3} \cdot v^3 D^2$ [kW]. For D = 20 m and v = 6 m/sec (mean yearly wind velocity in the north German region) we find N_e = 20 kW. Assuming an available tower /96 height of 100 m, we find that the average effective power is $N_e \approx$ 100 kW for five wind wheels arranged above each other.

b) Wind wheels with vertical axis

The wind wheels can also be constructed with a vertical axis, for example the so-called Savonius rotors. These rotors have blades in the shape of a semicircle which are attached to the axis. The concave surfaces of the blades receive the drag forces of the wind, independent of the wind direction. This means that no special devices for orientation with respect to the wind are necessary for the wind wheel. Because there is no heavy gondola, substantial simplifications and cost reductions occur.*

Figure 2 shows one installation, but differs somewhat from the solution of Savonius. The entire antenna mast, which can also be used as an oscillating medium wave band antenna, is used as a fixed "or rotatable" rotor axis. The FM antennas are installed on upper supports which are fixed by guy wires or with a fixed yoke if there are twin towers. In order to increase the resistance to storms and in order to reduce the power costs, it is possible to use the usual tower construction methods with several guy wires (this means that the expenses fish belly construction does not have to be used) and the rotor blade system can be divided up into several floors. The force transmission system is designed in a corresponding way (for example liquid drive or individual generators for each floor).

The calculations of A. Betz [3] give an idea of the power levels which can be achieved. Because of the reduced efficiency which is a consequence of exploiting only the drag forces, the average effective power level is

$$N_c = 0.1 \cdot 10^{-3} \cdot F \cdot v^3 \text{ [kW]}$$

(F = effective area).

* It is true that primarily the drag forces (which are lower) of the wind are exploited in such rotor arrangements. This reduces the aerodynamic efficiency well below the efficiencies of wind wheels which use the larger lift forces. Nevertheless, since there is a free supply of wind, such solutions should not be rejected to begin with. The only important thing is the costs which must be investigated for each individual case.

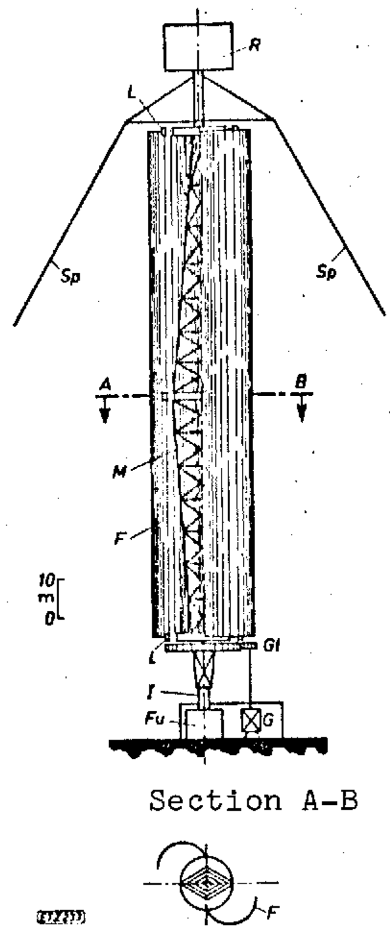

Figure 2. Principle of an antenna tower with Savonius wind rotor.

F- blades; Fu- foundation; G- generator; Gt- gears,
I- insulator; L- bearings; M- mast; R- directional antenna
Sp- guy wires

Again assuming a tower with a 100 m effective height and a rotor radius of 10 m, that is with an effective area of 1000 m^2, for a "normal" exploitable wind velocity of 6 m/sec we find the effective power to be

$$N_e = 20\,\mathrm{kW};$$

for a wind velocity of 10 m/sec the power level would be about 100 kW.

Even though these theoretical performance levels are smaller than those which can be obtained with wind wheels, in any comparison it must be realized that a rotor system has various other advantages, such as easier starting conditions, higher rotation rate, and the fact that it is independent of the wind direction. Also it is not sensitive to large wind velocities,* etc.

SUMMARY

It is proposed that antenna towers be used for wind power generating stations. Considering the new FM and television transmitter structures which must be built, it becomes possible to use the antenna towers for two purposes. The exploitation conditions are basically the same for both. The required tower heights are approximately the same because the wind must be unobstructed and the radiation must propagate freely. The power level required to operate the transmitter stations and the power level delivered by the wind power generating stations are approximately the same. The transmitters must have emergency power supplies if the power fails and also during periods of no wind. There is no variation in the construction with location and additional high costs of supply cables are saved.

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* At high wind velocities, the laminar flow at the tips of the convex propeller surfaces becomes turbulent, which means that the power increase is less than the third power of the wind velocity. In practice this means a certain advantage, because this effect limits the installed power level. This has a favorable effect on the economical operational calculations, because the proportion of high wind velocities over the year is only relatively small. However, the maximum velocities determine the installed (higher) power level for wind wheels.

In cases where the tips of the towers are already occupied by existing FM and other antennas, there are several constructions which have been discussed in detail. In particular, wind wheels with a horizontal axis can be installed about three quarters of the mast length from the ground, such as the Savonius rotors. Also there are those with vertical axes.

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